

On the rotation of the universe

Yuri N. Obukhov^{1,2}, Vladimir A. Korotky^{2,3}, and Friedrich W. Hehl¹

¹*Institute for Theoretical Physics, University of Cologne, D-50923 Köln, Germany*

²*Department of Theoretical Physics, Moscow State University, 117234 Moscow, Russia*

³*Department of Mathematics, Yaroslavl State Technical University, 150023 Yaroslavl, Russia*

Recently Nodland and Ralston [1] have analyzed the data on polarized electromagnetic radiation from distant radio sources. The dipole effect of the rotation of the plane of polarization was reported in the form $\beta = \frac{1}{2}\Lambda_s^{-1}r \cos \gamma$, where β is the residual rotation angle between the polarization vector and the direction of the major axis of a source (remaining after the Faraday rotation is extracted), r is the distance to the source, γ is the angle between the direction of the wave propagation and the constant vector \vec{s} . The analysis of data for 160 radio sources yielded [1] the best fit for the constant $\Lambda_s = (1.1 \pm 0.08) \frac{2}{3} \frac{10^{15}}{H} \text{ m yr}^{-1}$ (with the Hubble constant H), and the \vec{s} -direction RA (21h±2h), dec ($0^\circ \pm 20^\circ$).

In an attempt to explain their observations, Nodland and Ralston concluded that it is impossible to understand such an effect within conventional physics. Instead, they considered a modified electrodynamics with the Chern-Simons-type term violating Lorentz invariance [2], and related Λ_s to the coupling constant of that term.

In this comment we want to point out a different explanation: global cosmic rotation. It is of purely geometrical origin and is completely within conventional physics. Quite early [3], cosmological models with rotation (and, in general, with shear) attracted considerable attention. For the *mixed* effects of global vorticity and shear strong limits are known (see, e.g., [4]) on the value of rotation. However, shear and rotation manifest themselves differently in observations. If one carefully distinguishes them, one finds substantially weaker limits on the cosmic vorticity [5,6].

Rotation of polarization of an electromagnetic wave is a typical effect of the cosmic rotation. Actually, not only polarization but, in general, all other optical characteristics of an image (size, shape, orientation) are affected by the curvature of spacetime [7]. The specific effect reported by Nodland and Ralston, and earlier by Birch [8], can be extracted from the geometry of bundles of null geodesics (rays) as follows: After solving the null geodesics equations, one can construct a Newman-Penrose null frame $\{l, n, m, \bar{m}\}$ in such a way that l coincides with the wave vector k , and the rest of the vectors are covariantly constant along l . Then we can identify a polarization vector with, e.g., m . If we now consider the deformation of a source's image *with respect to that frame*, the angle between the major axis of an image and m will be exactly the observable relative angle β .

For a wide class of viable spatially homogeneous rotating models [5,6], combining the knowledge of explicit solutions for the null geodesics equations with the Kristian-Sachs expansion technique, one finds

$$\beta = \omega r \cos \gamma + O(Z^2), \quad (1)$$

where ω is the present magnitude of the rotation and γ is the angle between the direction to a source and the direction of the cosmic vorticity. Higher angular corrections quadratic in the red shift Z are not displayed. Recalling [1] the value of Λ_s , we immediately find

$$\frac{\omega}{H} = 6.5 \pm 0.5. \quad (2)$$

This is larger than the estimate [5] obtained earlier on the basis of Birch's data [8]. Also the direction of \vec{s} , which we now interpret as the direction of the cosmic vorticity, is different from the older estimate RA (12h±2h), dec ($-35^\circ \pm 30^\circ$), based on the observations of Birch [5,6]. However, within the error limits, the two directions are orthogonal to each other.

We hope that the new data of Nodland and Ralston may provide, as compared to Birch's results, a substantially improved estimate of the magnitude and direction of the cosmic rotation. It is worthwhile to stress again that our explanation of the dipole anisotropy in observations of polarization of radio sources is *within* conventional general relativity. The value (2) is *not* in conflict with other observational data (in particular, not with the limits of anisotropy of the microwave background radiation), see [5,6]. Cosmological rotation may be significant for models of galaxy formation [9].

Here we do not intend to enter the discussion [10] on the statistical significance of the results of Nodland and Ralston. Evidently, further careful observations and statistical analyzes will be extremely important in establishing the true value or finding upper limits for cosmic rotation.

-
- [1] B. Nodland and J.P. Ralston, *Phys. Rev. Lett.* **78**, 3043 (1997).
 - [2] S.M. Carroll, G.B. Field, and R. Jackiw, *Phys. Rev.* **D41**, 1231 (1990).
 - [3] K. Lanczos, *Zeits. f. Phys.* **21**, 73 (1924); G. Gamow, *Nature* **158**, 549 (1946); K. Gödel, *Rev. Mod. Phys.* **21**, 447 (1949).
 - [4] S.W. Hawking, *MNRAS* **142**, 129 (1969); C.B. Collins and S.W. Hawking, *MNRAS* **162**, 307 (1973); J.D. Barrow, R. Juszkiewicz, and D.H. Sonoda, *MNRAS* **213**, 917 (1985).
 - [5] Yu.N. Obukhov, *Gen. Rel. Grav.* **24**, 121 (1992).
 - [6] V.A. Korotky and Yu.N. Obukhov, *Sov. Phys. JETP* **72**, 11 (1991); *JETP* **81**, 1031 (1995).
 - [7] J. Kristian and R. Sachs, *Astrophys. J.* **143**, 379 (1966); G.F.R. Ellis, in: *General Relativity and Cosmology* (Rendiconti S.I.F., Corso XLVIII, Varenna, 1969), Ed. R.K. Sachs (Academic Press: New York, 1971) 104.
 - [8] P. Birch, *Nature* **298**, 451 (1982); *ibid* **301**, 736 (1982).
 - [9] J. Silk, *MNRAS* **147**, 13 (1970); L. Li, astro-ph/9703082.

- [10] D.J. Eisenstein and E.F. Bunn, astro-ph/9704247; S.M. Carroll and G.B. Field, astro-ph/9704263; B. Nodland and J.P. Ralston, astro-ph/9705190.